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The information displayed in this Appendix was used by NDOR to develop refined cost estimates for each of the alternatives. These technical memoranda and other documentation were developed prior to completion of alternative practicability screening. The information contained within the Bridge Design Considerations shows the criteria NDOR considered in its design. The information contained within the Pierre Shale Mitigation shows the considerations NDOR evaluated to mitigate Pierre shale slides. Finally, the information contained within the Proposed Culvert and Bridge Sizes tables are the proposed structures NDOR implemented in its cost estimates.

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BRIDGE DESIGN CONSIDERATIONS

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Memorandum

DATE July 1, 2014
TO Jim Knott, Roadway Design Engineer
FROM Joel Rossman, Assistant State Bridge Engineer
THRU Mark Traynowicz, State Bridge Engineer
SUBJECT Niobrara East and West
Project No. S-12-5(1011), CN 31674
Bridge Engineering Review



The senior bridge staff met with Lorraine Legg, Jennifer Thompson and Andrew Mansfield on Friday, May 2, 2014 to discuss bridge structures for the various, alternate roadway alignments on the subject project. As an outcome of the discussions in that meeting, Bridge Division formulated the following to describe challenges anticipated for the structures as this project moves forward.

NDOR employs bridge design strategies for new structures that provide for long life, straightforward construction and minimal maintenance; all without excessive increases in initial construction cost. The routine preventative maintenance and eventual repair/reconstruction will be a long term responsibility of NDOR, and considering the number and length of potential bridges on this project, those costs could be substantial if not adequately considered at the time of design and initial construction. Providing well designed, thoroughly vetted, preservation enhanced structures will pay dividends to the Nebraska Department of Roads over the life of these structures.

This memorandum summarizes the results of a bridge engineering review of proposed bridges on the alternative alignments under consideration for the Niobrara East and West reconstruction project.

The following information was utilized in this review:

- Alternative concept designs provided by the Roadway Design Division
- NDOR Bridge Office Policies and Procedures (BOPP) Manual
- NDOR Bridge Division Historical Data and Recommendations

Based on our review of this information and our internal meetings, we have the following recommendations:

Bridge Length Limitations

In order to eliminate problematic expansion devices in the bridge deck, a bridge length limitation of 1,400 feet will be utilized. We have been successful with straight (non-curved alignment) bridge lengths up to this limit. When considering a curved alignment, the length will need to be reduced due to the two dimensional nature of the linear displacement of the superstructure. Maximum bridge length in these situations is difficult to determine because of variability in radius of the horizontal curve. Each bridge will need to be evaluated on a case by case basis but we anticipate the length will be substantially less than the aforementioned 1,400 feet and more likely closer to a 1,000 feet limit. Additionally, a minimum distance of 500' is recommended between bridges (measured from end of floor to end of floor). This distance should provide a sufficient gap between the guardrail on each structure to allow access to be provided to adjacent properties.

Horizontal Alignment for Bridges

The Bridge Division would prefer to keep bridges on tangent alignments and without skew wherever possible. Curved bridges and bridges in transitions to superelevated curves result in more complex design and construction resulting in lower quality construction and higher costs. These are just a few of the disadvantages to constructing bridges on curved alignments. In situations where a curved alignment is unavoidable, measures can be taken to achieve high quality structures with limited construction difficulties but at additional cost. We strongly encourage (1) ensuring that none of the bridge structure is in a superelevation transition section and that (2) the roadway alignment uses the maximum possible radius for the curved alignments. To ensure that none of the bridge is in a superelevation transition zone requires a significant distance of embankment between bridge structures on segments of roadway with reverse curvature.

Deck Protection/Preservation

Incorporating a deck protection system into the initial construction will extend the service life of these structures.

Historical data suggests that the waterproof membrane overlay applications are very successful at prohibiting chlorides from contaminating the deck and therefore protecting the superstructure for many years. As part of our Bridge Management strategies, we have criteria for installing epoxy polymer overlays or waterproof membranes (incorporated with an asphalt overlay) on existing bridge decks. Epoxy polymer overlays (EPO's), while providing deck protection also result in a high friction surface course that is very effective at providing vehicular traction during winter precipitation events. EPO's will need to be reapplied approximately every five years.

Additional techniques, such as the incorporation of a closed concrete rail on the bridge, will greatly extend the life of the bridge deck edge. Although use of an open rail could enhance the ability of bridge deck to drain, utilizing open concrete rails would necessitate the replacement of the rail and deck edge (2'-6" cantilever section) after approximately 20 years. Sealing the deck and deck edge with a preservative and reapplying approximately every five years may help to increase deck longevity in this case.

Steel superstructure elements such as the ends of weathering steel girders should include zone painting and steel substructure elements such as exposed steel piling should include protection measures such as shop and/or field painting.

The selection of the type of bridge joint will be critical to the life of the bridge and will need to take into consideration the needs of routine preventative maintenance.

Additional Considerations

Alignments located in landslide prone areas or in areas of problematic geology will require extensive substructure analysis and complicated and costly substructure construction details such as deeply founded, large diameter drilled shafts.

Bridges on this project will be built with improved end of bridge drainage details. Specifically pavement drains will be located in the section of roadway prior to (or just past) the bridge paving section. Pavement drains will not be located in the bridge approach slab or bridge paving section.

Cost

The Bridge Division has updated the cost estimates for the bridges based on the following criteria:

- Horizontally curved alignments, or alignments in superelevation transition
- Construction in a remote location and the difficulty of contractor mobilization
- Construction of temporary bridges for construction, contractor work platforms
- Construction of tall piers; Alignment B1 will require special designs to accommodate the propensity for slides
- Construction of long spans; Alignment B1 may necessitate use of spans of 300 feet or more, these spans lengths will require special design and construction methods

CN 31674, S-12-5(1011), Niobrara East and West – Preliminary Bridge Construction Cost & Justification

Notes:

- These are today's costs and not adjusted for economic inflation at a later date in time.
- This estimate is not based on one type of bridge rather on the competitive bid philosophy between a concrete girder bridge and a steel girder bridge.
- Remote location is considered. Add 15% to Baseline cost/SqFt
- Mobilization is not included.
- Waterproof membrane with an asphalt overlay will be incorporated into the original construction documents. Add \$5/SqFt
- Approach Slab and Paving Section Costs (including approach rails, buttresses, grade beams and piling) are not included in these costs. Bridge management currently uses approximately \$40/SqFt of Approach Section. 2-50' Approach Sections = \$190K. I would add \$200K to each bridge for the Approaches.
- Contractor work platforms are not included in these costs. This will be a temporary work platform (temporary bridge) 30' wide, for the full length of the proposed bridge and removed following construction. Add \$60/SqFt (of work platform) or \$1800/LF.
- Guard Rail is not included in these costs.
- Span lengths are assumed to be limited to approximately 150' for "typical" bridges.
- Width of East Structures: 40' Clear, 2-1'-2" Bridge Rails with 2" edge distance = 42'-8" Out to Out
- Width of West Structures: 36' Clear, 2-1'-2" Bridge Rails with 2" edge distance = 38'-8" Out to Out
- Skewed Structures will add an additional 5% to the baseline cost of the bridge.
- Curved Structures will add an additional 10% to the baseline cost of the bridge.
- Structures that have complicated construction requirements (tall piers or long spans) will add an additional 25% to the baseline cost of the bridge.
- Any contingency allowance is not included.

Straight (Non-Curved) Bridges:

Baseline costs per SqFt.

Average costs for typical (girder/deck) bridge construction = \$134/SqFt

Total cost = $(\$134(1.15) + \$5) = \$159/\text{SqFt}$

Skewed Bridges:

Baseline costs:

Average costs for typical (girder/deck) bridge construction = \$134/SqFt

Total cost = $(\$134(1.15*1.05) + \$5) = \$167/\text{SqFt}$

Curved Bridges:

Baseline costs:

Average costs for typical (girder/deck) bridge construction = \$134/SqFt

Total cost = $(\$134(1.15 \times 1.10) + \$5) = \$175/\text{SqFt}$

Complicated Construction Requirements:

Baseline costs:

Average costs for typical (girder/deck) bridge construction = \$134/SqFt

Total cost = $(\$134(1.15 \times 1.25) + \$5) = \$198/\text{SqFt}$

CN 31674

Project No. S-12-5(1011)

Niobrara East and West

Preliminary Bridge Construction Cost

East Structures
West Structures

| Alternate A1 | | | | | | | | |
|----------------|-------------|------------|-------------------------|--------|--------|--------------------------|---------------|-------------------|
| Bridge Station | Length (Ft) | Width (Ft) | Bridge Deck Area (SqFt) | Skewed | Curved | Complicated Construction | Cost Per SqFt | Total Bridge Cost |
| 1247+00 | 920 | 42.67 | 39,253.33 | No | Yes | No | \$175 | \$6,869,333 |
| 1428+00 | 280 | 38.67 | 10,826.67 | No | No | No | \$159 | \$1,721,440 |
| 1462+00 | 160 | 38.67 | 6,186.67 | No | No | No | \$159 | \$983,680 |
| 1471+00 | 150 | 38.67 | 5,800.00 | No | No | No | \$159 | \$922,200 |
| 1591+00 | 89 | 38.67 | 3,441.33 | No | No | No | \$159 | \$547,172 |

Alternate A1 Total \$11,043,826

| Alternate A2 | | | | | | | | |
|----------------|-------------|------------|-------------------------|--------|--------|--------------------------|---------------|-------------------|
| Bridge Station | Length (Ft) | Width (Ft) | Bridge Deck Area (SqFt) | Skewed | Curved | Complicated Construction | Cost Per SqFt | Total Bridge Cost |
| 2248+00 | 1020 | 42.67 | 43,520.00 | No | Yes | No | \$175 | \$7,616,000 |
| 2427+00 | 280 | 38.67 | 10,826.67 | Yes | No | No | \$167 | \$1,808,053 |
| 2462+00 | 160 | 38.67 | 6,186.67 | Yes | No | No | \$167 | \$1,033,173 |
| 2471+00 | 150 | 38.67 | 5,800.00 | No | No | No | \$159 | \$922,200 |
| 2591+00 | 89 | 38.67 | 3,441.33 | Yes | No | No | \$159 | \$547,172 |

Alternate A2 Total \$11,926,599

| Alternate A3 | | | | | | | | |
|----------------|-------------|------------|-------------------------|--------|--------|--------------------------|---------------|-------------------|
| Bridge Station | Length (Ft) | Width (Ft) | Bridge Deck Area (SqFt) | Skewed | Curved | Complicated Construction | Cost Per SqFt | Total Bridge Cost |
| 3251+00 | 1020 | 42.67 | 43,520.00 | No | Yes | No | \$175 | \$7,616,000 |
| 3427+00 | 280 | 38.67 | 10,826.67 | No | No | No | \$159 | \$1,721,440 |
| 3462+00 | 160 | 38.67 | 6,186.67 | No | No | No | \$159 | \$983,680 |
| 3471+00 | 150 | 38.67 | 5,800.00 | No | No | No | \$159 | \$922,200 |
| 3595+00 | 190 | 38.67 | 7,346.67 | No | No | No | \$159 | \$1,168,120 |
| 3693+00 | 300 | 38.67 | 11,600.00 | No | No | No | \$159 | \$1,844,400 |

Alternate A3 Total \$14,255,841

| Alternate A4 | | | | | | | | |
|----------------|-------------|------------|-------------------------|--------|--------|--------------------------|---------------|-------------------|
| Bridge Station | Length (Ft) | Width (Ft) | Bridge Deck Area (SqFt) | Skewed | Curved | Complicated Construction | Cost Per SqFt | Total Bridge Cost |
| 4067+00 | 525 | 42.67 | 22,400.00 | No | No | No | \$159 | \$3,561,600 |
| 4082+00 | 1050 | 42.67 | 44,800.00 | No | Yes | No | \$175 | \$7,840,000 |
| 4105+00 | 1400 | 42.67 | 59,733.33 | No | No | No | \$159 | \$9,497,600 |
| 4120+00 | 1400 | 42.67 | 59,733.33 | No | No | No | \$159 | \$9,497,600 |
| 4165+00 | 1400 | 42.67 | 59,733.33 | No | Yes | No | \$175 | \$10,453,333 |
| 4185+00 | 1275 | 42.67 | 54,400.00 | No | No | No | \$159 | \$8,649,600 |
| 4202+00 | 1300 | 42.67 | 55,466.67 | No | Yes | No | \$175 | \$9,706,667 |
| 4225+00 | 700 | 42.67 | 29,866.67 | No | Yes | No | \$175 | \$5,226,667 |
| 4247+00 | 1000 | 42.67 | 42,666.67 | No | Yes | No | \$175 | \$7,466,667 |
| 4428+00 | 280 | 38.67 | 10,826.67 | Yes | No | No | \$167 | \$1,808,053 |
| 4462+00 | 160 | 38.67 | 6,186.67 | Yes | No | No | \$167 | \$1,033,173 |
| 4471+00 | 150 | 38.67 | 5,800.00 | No | No | No | \$159 | \$922,200 |
| 4591+00 | 89 | 38.67 | 3,441.33 | Yes | No | No | \$167 | \$574,703 |
| 4610+00 | 1400 | 38.67 | 54,133.34 | No | No | No | \$159 | \$8,607,201 |
| 4625+00 | 1400 | 38.67 | 54,133.34 | No | No | No | \$159 | \$8,607,201 |
| 4640+00 | 1400 | 38.67 | 54,133.34 | No | No | No | \$159 | \$8,607,201 |
| 4660+00 | 1400 | 38.67 | 54,133.34 | No | No | No | \$159 | \$8,607,201 |
| 4680+00 | 1400 | 38.67 | 54,133.34 | No | Yes | No | \$175 | \$9,473,334 |
| 4705+00 | 1400 | 38.67 | 54,133.34 | No | No | No | \$159 | \$8,607,201 |

Alternate A4 Total \$128,747,201

| Alternate A7 | | | | | | | | |
|----------------|-------------|------------|-------------------------|--------|--------|--------------------------|---------------|-------------------|
| Bridge Station | Length (Ft) | Width (Ft) | Bridge Deck Area (SqFt) | Skewed | Curved | Complicated Construction | Cost Per SqFt | Total Bridge Cost |
| 7180+00 | 1400 | 42.67 | 59,733.34 | No | No | No | \$159 | \$9,497,601 |
| 7195+00 | 800 | 42.67 | 34,133.33 | No | No | No | \$159 | \$5,427,200 |
| 7205+00 | 800 | 42.67 | 34,133.33 | No | No | No | \$159 | \$5,427,200 |
| 7225+00 | 1025 | 42.67 | 43,733.33 | No | No | No | \$159 | \$6,953,600 |
| 7240+00 | 525 | 42.67 | 22,400.00 | No | Yes | No | \$175 | \$3,920,000 |
| 7250+00 | 1022 | 42.67 | 43,605.33 | No | Yes | No | \$175 | \$7,630,933 |
| 7427+00 | 280 | 38.67 | 10,826.67 | Yes | No | No | \$167 | \$1,808,053 |
| 7462+00 | 160 | 38.67 | 6,186.67 | Yes | No | No | \$167 | \$1,033,173 |
| 7471+00 | 150 | 38.67 | 5,800.00 | No | No | No | \$159 | \$922,200 |
| 7595+00 | 190 | 38.67 | 7,346.67 | No | No | No | \$159 | \$1,168,120 |
| 7662+00 | 625 | 38.67 | 24,166.67 | No | No | No | \$159 | \$3,842,500 |
| 7671+00 | 425 | 38.67 | 16,433.33 | No | Yes | No | \$175 | \$2,875,834 |
| 7680+00 | 950 | 38.67 | 36,733.34 | No | No | No | \$159 | \$5,840,601 |
| 7692+00 | 950 | 38.67 | 36,733.34 | No | No | No | \$159 | \$5,840,601 |

Alternate A7 Total \$62,187,616

| Alternate B1 | | | | | | | | |
|----------------|-------------|------------|-------------------------|--------|--------|--------------------------|---------------|-------------------|
| Bridge Station | Length (Ft) | Width (Ft) | Bridge Deck Area (SqFt) | Skewed | Curved | Complicated Construction | Cost Per SqFt | Total Bridge Cost |
| 8137+00 | 773 | 42.67 | 32,981.34 | No | No | Yes | \$198 | \$6,530,305 |
| 8285+00 | 1169 | 42.67 | 49,877.33 | No | No | Yes | \$198 | \$9,875,712 |
| 8428+00 | 280 | 38.67 | 10,826.67 | No | No | No | \$159 | \$1,721,440 |
| 8462+00 | 160 | 38.67 | 6,186.67 | No | No | No | \$159 | \$983,680 |
| 8471+00 | 150 | 38.67 | 5,800.00 | No | No | No | \$159 | \$922,200 |
| 8597+00 | 1029 | 38.67 | 39,788.00 | No | No | Yes | \$198 | \$7,878,025 |

Alternate B1 Total \$27,911,362

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Executive Summary

Following Mark Lindemann's field inspection of the B1 Alignment, a meeting was held on February 28th, 2013. The purpose of this meeting was to discuss the issues and impact associated with geotechnical concerns with the areas of shale along the proposed alignment. The following people were in attendance:

| | |
|-------------------|----------------------------------|
| Jim Knott | Roadway Design, Engineer VII |
| Jason Jurgens | Environmental Section Manager |
| Mark Traynowicz | Bridge, Engineer VII |
| Mike Vigil | Bridge Management, Engineer V |
| Mark Ahlman | Bridge, Engineer V |
| Jamie Reinke | Bridge, Engineer IV |
| Walter Rutherford | Bridge, Engineer IV |
| Mark Lindemann | Materials & Research, Engineer V |
| Lou Lenzen | Roadway Design, Engineer V |
| Chris Lutz | Roadway Design, Engineer III |
| Andrew Mansfield | Roadway Design, Engineer II |

Typical Mitigation Measures

Mark Lindemann identified three typical solutions for mitigating the existing and future shale slides in the area.

A Typical Fill Section (see Exhibit A) will require a minimum of 3' of granular fill with 3 layers of geogrid. If the proposed grade is only 1' above the existing grade, this area will require additional 2' of over-excavation in order to place the required 3' of granular material. Toe keys will need to be placed at the bottom of the foreslopes and standard trench underdrains will also be required. Additional fill (above the 3' minimum granular fill) required to meet the vertical profile can be any material, but due to concerns with the availability of suitable material, this too will most likely be granular material.

A Typical Cut Section (see Exhibit B) will have the roadway placed on 3' of granular fill with 3 layers of geogrid; this will require 3' of over-excavation to allow for placement of this granular material. Backslopes will need to be flatter than 4:1's to prevent slides and will require a network of horizontally drilled drains to attempt to dewater the shale and prevent future slides. The horizontal drains are installed in a grid pattern with horizontal and vertical spacing varying from 25'-50' and are installed at an angle of 2°-5°. The length of these drains is dictated by the depth of the cut and the location of the pipe. For example, in a 30' cut section, the pipe at the bottom of the ditch will need to be 30' long. These drains are then connected together with a collection system to prevent the water collected from flowing down the backslopes or ditch. This collection system will then need to be outletted into cross-culverts to allow the water to flow away from the roadway. These drains have an average cost of \$30-40/ft and will require

maintenance approximately every 8 years to clean out any collected sediment present in the drains. This will require additional property rights for the entire length of the pipe and access to each level of the drains.

A Problem Cut Section (see Exhibit C) will have all of the same elements of the Typical Cut Section above with the addition of bench cutting the backslope and the placement of toe berms. The bench cuts will require the placement of cohesive soils to stabilize the slopes and prevent additional slides. Then toe berms will need to be placed at the bottom of the backslope to prevent future slippage. Toe berms are normally constructed out of Rip-Rap and are typically 15' wide and 10' tall but will need to be designed on a case by case basis. These berms will be placed in the roadside ditches and as a result, these ditches will need to be widened to accommodate this additional width.

In addition to the aforementioned mitigation measures, Mark also identified the following areas of concern with this alignment:

- A large percentage (Mark thinks 60-70%) of the excavated material (shale) will not be allowed for use as fill material and will need to be disposed of.
- Availability of suitable material to be used as fill. There is granular material available but it is 5-10 miles away.
- Due to the issues with the availability of suitable fill material, most of the fill material will most likely be granular. This will require topsoil to be brought in as part of this project to encourage vegetation growth.
- Proposed culverts will need to be backfilled with granular material. This presents a problem with preventing water from flowing along the outside of the culverts and carrying away the fill material.
- Roadside ditches will need to be wider than our typical 10' to account for sloughing of the foreslope/backslope and for the placement of toe berms.
- The proposed bridges will need to be lengthened so that the abutments and approaches are not placed in fill sections.
- In areas of both cuts and fills, the top of the small knobs will need to be removed prior to placing fill or will be over-excavated to prevent possible future slides.
- Issues with providing construction access due to the lack of suitable roads and issues with access during and after rain.
- Due to issues with possible shale slides, some of the bridges may require drilled shafts.
- Several areas where culverts are proposed may work better as bridge structures. These would be bridges not due to concerns with hydraulic capacity but to eliminate fill areas and mitigate stability problems.

Action Items

The following is a list of action items and items of additional investigation as a result of this meeting:

- Updated bridge lengths to eliminate the need for placing the approaches or abutments in fill sections (Bridge)
- Temporary Bridge Recommendations (Bridge Hydraulics)
- Re-evaluation of culvert recommendations to see if a bridge sized structure may be more appropriate (Bridge and Bridge Hydraulics)
- Mitigation measures for preventing seepage through the granular fill around proposed pipes and box culverts (Special Plans Unit)
- Additional cost for excavating, crushing and sizing the Chalk material (Construction)
- What stabilization measures would be required to stabilize the sand subgrade to provide access during construction (Materials and Research)
- Meeting with Mark Lindemann to further discuss mitigation guidance to be provided to Benesch (Roadway Design)
- Meeting with Benesch to clarify the scope of additional work required (Roadway Design)
- Meeting with the US Army Corps of Engineers to discuss the profile changes in relation to the update roadway overtopping issues with the "A" Alignments (Roadway Design)
- Investigation of possible alignment shifts to the south to avoid building on the side of existing shale slides on the West segment near STA 8625+00 and to avoid the calving operations near STA 8600+00 (Roadway Design)

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EXHIBIT A

Typical Fill Section Design

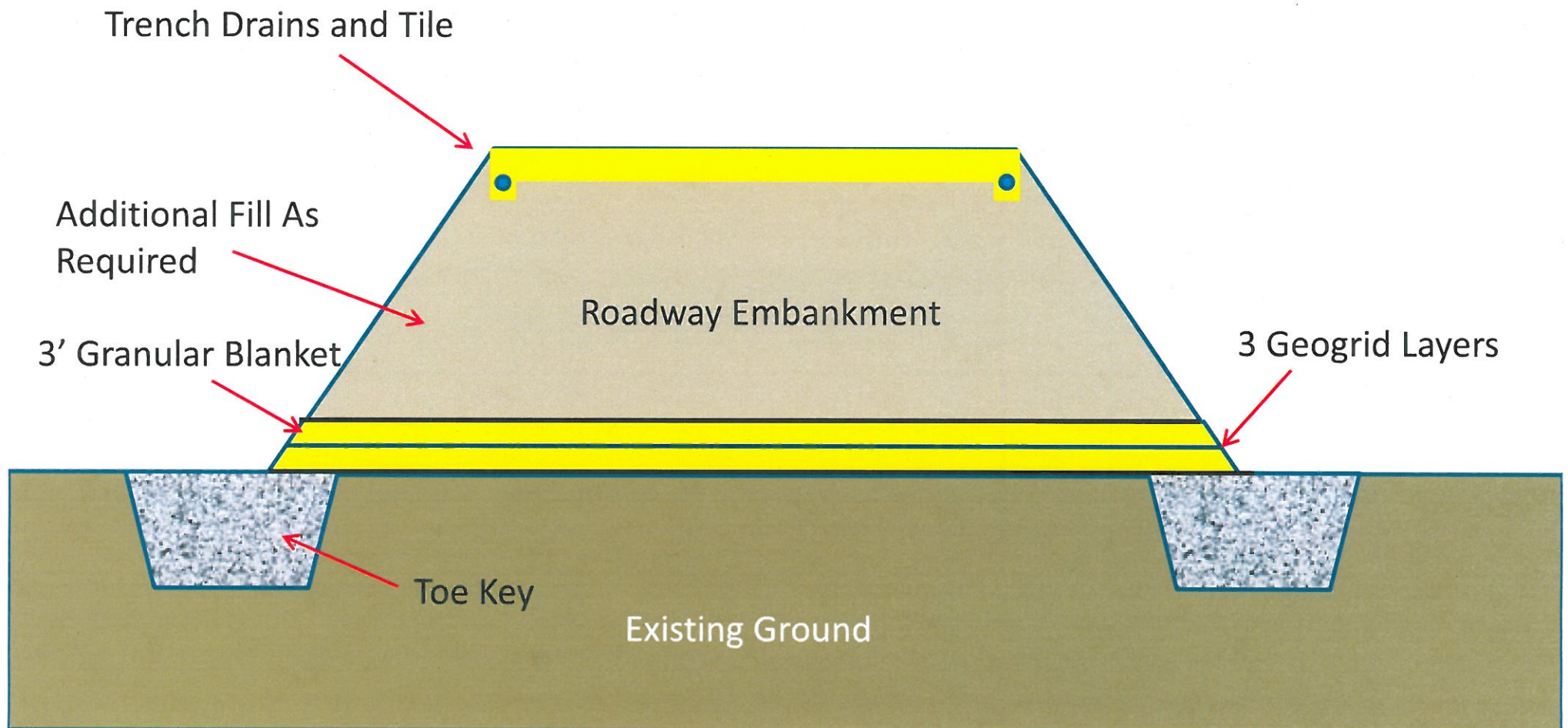
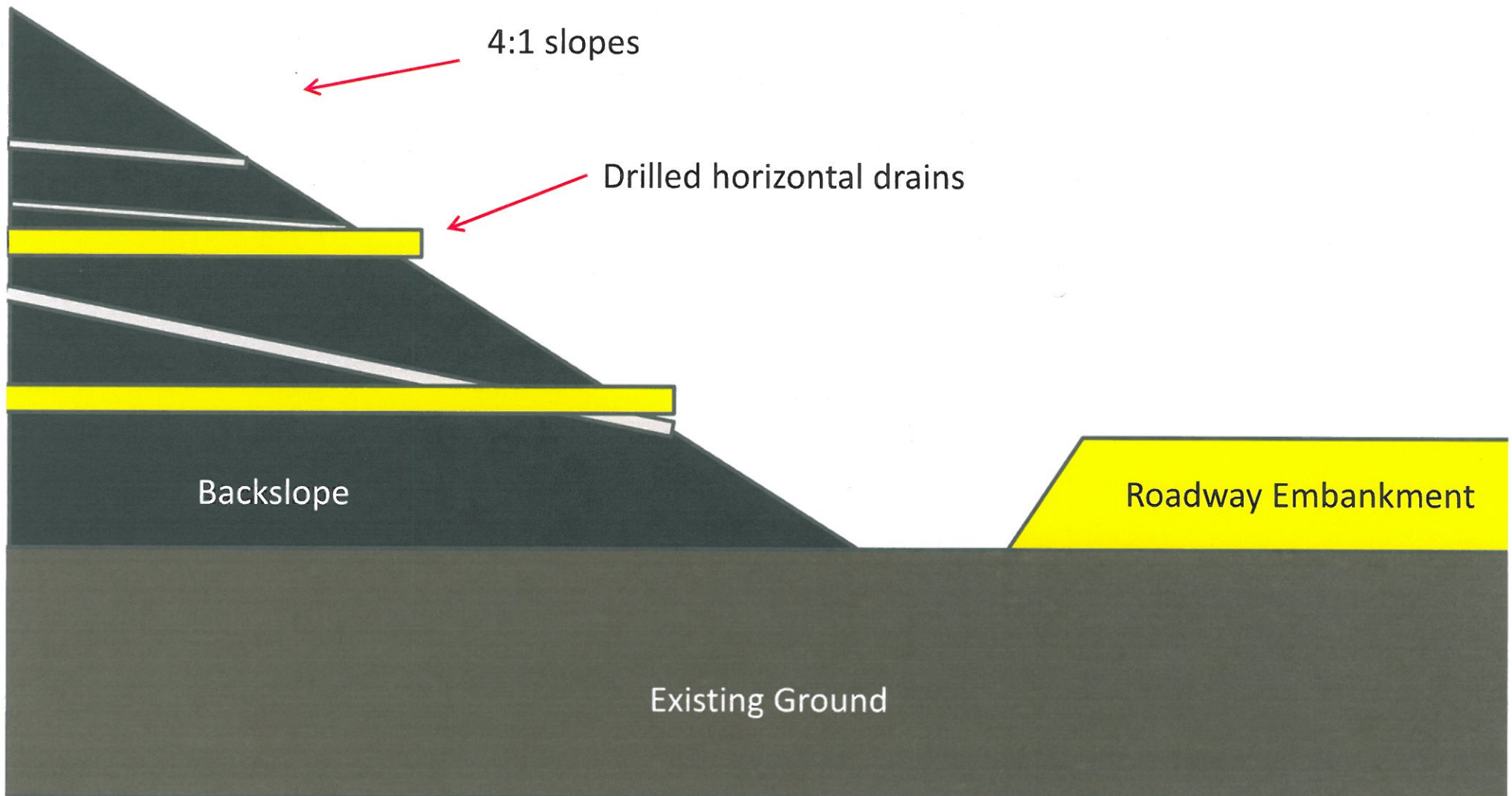


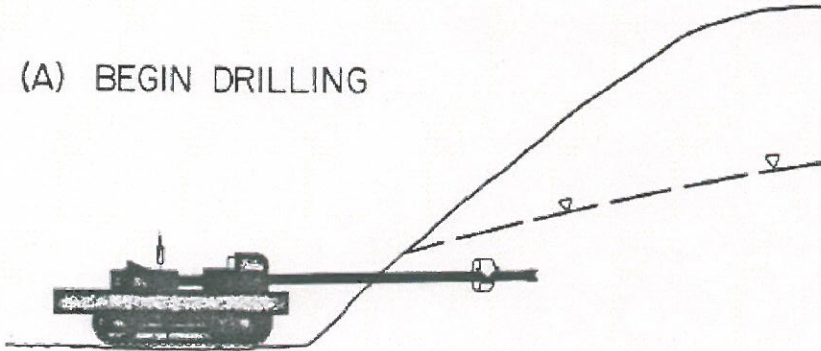
EXHIBIT B

Typical Shale Cut-Slope Design

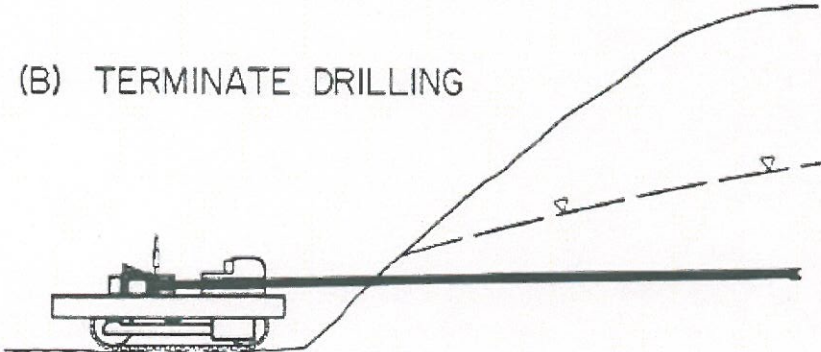


Horizontal Drilled Drains

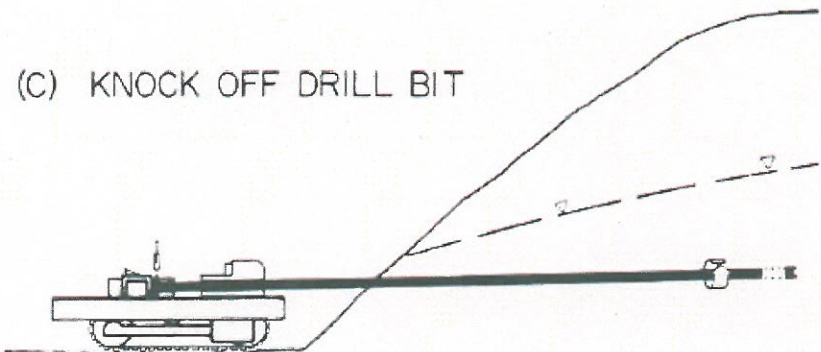
(A) BEGIN DRILLING



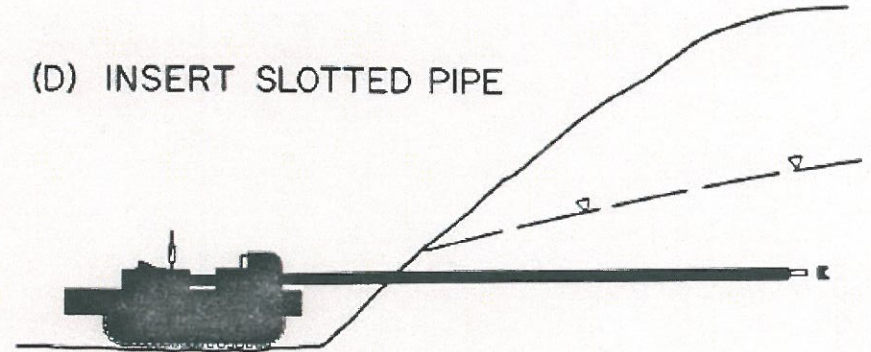
(B) TERMINATE DRILLING



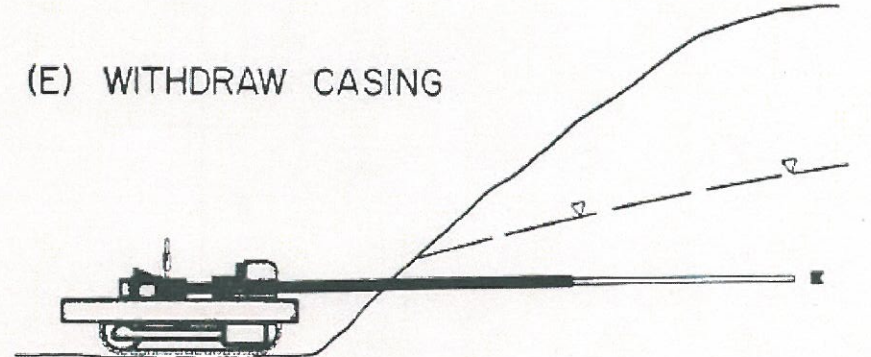
(C) KNOCK OFF DRILL BIT



(D) INSERT SLOTTED PIPE



(E) WITHDRAW CASING



(F) COMPLETED DRAIN

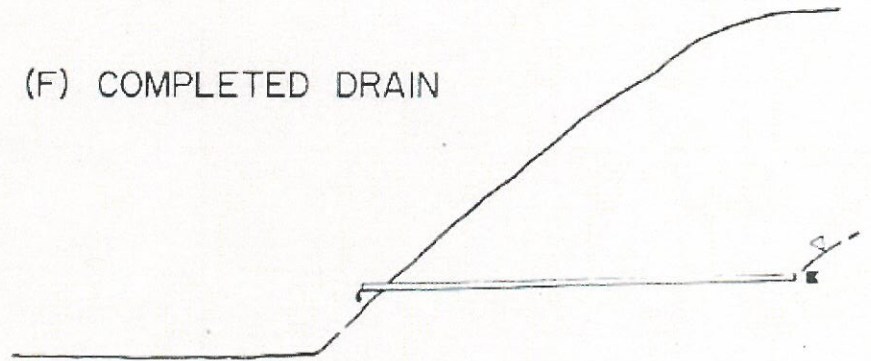
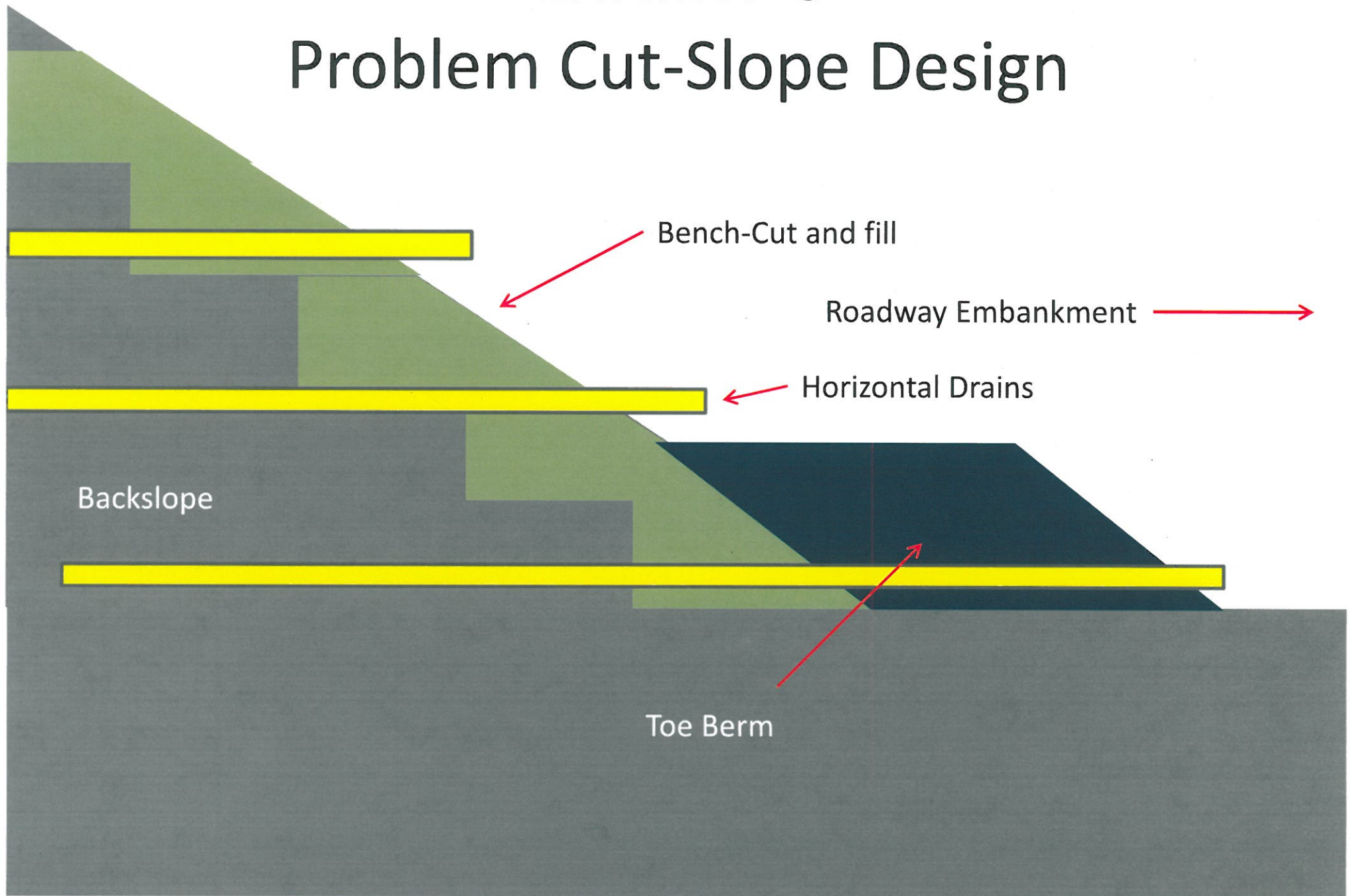


EXHIBIT C


Problem Cut-Slope Design



Materials and Research Division
Geotechnical Section

Date: April 4, 2013

To: Lou Lenzen, Roadway Design

From: Mark Lindemann, Geotechnical Engineer 

Subject: Summary Report of Proposed Slide Mitigation for Alternative B1
Niobrara East & West 12-5(1011), CN 31674

The Geotechnical Section has performed a site reconnaissance of the referenced project in order to provide preliminary recommendations for the prevention of slide occurrence within cut and fill sections of the project as well as other negative effects the shale material has on roadway construction.

The proposed B1 alignment is situated on the upland portion of the Pierre Shale Plains and Hills region where the greatest topographic relief in Knox County occurs. This area was previously blanketed with loess over-lying glacial till sands. Much of this loess and till material was removed through erosional processes leaving a high-relief topography consisting mostly of Pierre Shale capped occasionally with remnant loess and till sands. The Pierre Shale is a soft bedrock material that consists of high plastic clays that are thinly laminated with bedding planes often inclined at an angle. Although the material is classified as a soft-rock, it is very susceptible to weathering and erosion when exposed. As a result of these characteristics, the Pierre Shale has been associated with many landslides that have affected roadways in Knox County. Beneath the Pierre Shale is the Niobrara Formation, which consists of low to medium plastic siltstone and claystone (often called chalk). The Niobrara Formation will be exposed at some cut locations on the proposed alignment.

For the alignment west of Niobrara the maximum cut and fills are approximately 68 feet and 65 feet respectively. The alignment east of Niobrara has proposed cuts and fills of up to 115 feet and 68 feet, respectively. Through review of HWS' preliminary borings our own onsite evaluation, it is estimated that 60-70 percent of the soil material that will be encountered during construction of the proposed alignment will consist of shale.

Landslide Mitigation

The intent of the proposed mitigation techniques is to prevent, or at least minimize the potential for slope failures in the cut and fill areas of the proposed B1 alignment. It is very difficult to model the engineering characteristics of the Pierre Shale at the design stage because the properties change as a result of excavation, climate, changes in drainage, weathering, and the inclination of the shale deposit. It should be noted that the best mitigation method noted in the geotechnical practice field is to avoid construction within shale areas. The second most popular preventive measure is drainage control of both surficial and subsurface water.

Cut Mitigation Methods

Each cut-section should be evaluated on a case by case basis after a thorough subsurface investigation, laboratory testing, and analysis. The information provided are minimum recommendations based on observations in the field. Additional mitigation techniques may be warranted after a thorough drilling and testing program has been performed. Figure 1 shows a graphical presentation of the possible cut-slope mitigation measures.

- All slopes in cut-sections shall be constructed at 4H:1V.
- Drilled horizontal drains shall be installed at a horizontal and vertical spacing of 25'. The minimum length of the drains should be equal to the vertical distance from the toe of the cut-slope to the top of the cut section. Example: drains installed in a 50' cut-section should have a horizontal length of 50'. The drains are installed at a 2° to 5° inclination to allow for the gravitational flow of the groundwater. The approximate cost is \$30-\$40/ft.
- A water collection system consisting of a network of pipes, interceptor drains, and diversion ditches will be required to collect and divert both surface water run-off and subsurface water collected from the horizontal drains.
- In areas where the collection of subsurface water does not provide a satisfactory location to day-light water to lower areas, a pump system may be required.
- Beneath the roadway section a minimum of 3' of granular material will be required. This will require over-excavation and replacement with granular materials in cut-sections that bottom out in shale or other cohesive materials.
- Drain tile will be required at the bottom of ditches to collect any remaining water from the cut-slopes and the roadway section.
- Toe Berms or buttresses may be required in some cut-sections where failures already exist, where weathered shale is present, or where cut-sections are large. The berms act as a counterweight and consist of large rip-rap rock materials.

- Bench-cutting may be required where weathered shale is observed. The cut-slopes will be bench-cut and replaced with low to medium plastic cohesive soils (not the existing shale materials).

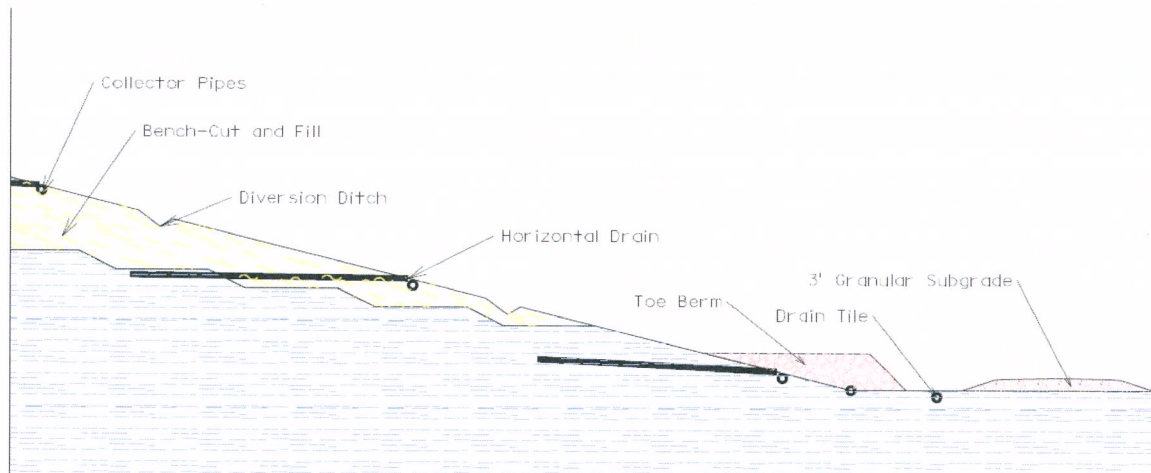


Figure 1. Cut-slope Mitigation Techniques

Embankment Mitigation Methods

As in the cut-section, each fill-section should be evaluated on a case by case basis. The information provided are minimum recommendations based on observations in the field. Additional mitigation techniques may be warranted after a thorough drilling and testing program has been performed. Figures 2 through 5 show graphical presentations of the possible embankment mitigation measures.

- All slopes in fill-sections shall be constructed at 4H:1V.
- Embankment material shall consist of either low-plastic clay, silt, or granular materials.
- Following clearing and grubbing operations weathered shale areas and existing slides shall be removed through bench-cut excavations. Existing “knobs” of shale shall be cut horizontally prior to fill placement to minimize any slip-plane failures.
- A 3' granular blanket with 3 layers of high strength biaxial geogrid shall be placed as a base stabilization layer prior to placing embankment materials. The geogrid shall extend past the outside edge of the constructed toe-keys (see below)

a minimum distance equal to the total depth of the toe-key. The granular blanket shall have a minimum friction angle of 34 degrees and maximum of 10% passing the #200 sieve. Drain tile shall be incorporated within the granular blanket to daylight any excess water within the embankment. If cohesive embankment materials are used a geotextile shall be placed atop of the granular blanket to prevent fine migration.

- In areas where the collection of subsurface water does not provide a satisfactory location to day-light water to lower areas, a pump system may be required.
- In sloped areas to receive fill, bench-cut excavations shall be made. Horizontal drains shall be installed in the same manner as described in the Cut-Slope mitigation section. A 3' thick granular blanket and 3 geogrid layers shall be placed within the bench-cut excavations to provide drainage and base reinforcement.
- At the toes of the embankment sections a toe-key shall be constructed to prevent deep-seated failures from within the shale underlying the embankment materials. The width and depth of the toe-key shall be based on embankment height and the engineering properties of the underlying shale. The toe-key shall be backfilled with a combination of rip-rap and granular materials and encapsulated with an impermeable geomembrane liner to prevent the migration of water into the toe-key excavation.
- Beneath the roadway section a minimum of 3' of granular material will be required to provide uniformity from transitions from cut-sections to fill sections.
- Subsurface trench drains will be required at the edge of the paved roadway sections to collect any surface water and prevent its migration into the embankment materials.
- Toe Berms may be required in some embankment locations where embankment loads are high or the engineering properties of the underlying shale dictates. The berms act as counterweight and consist of large rip-rap rock materials.

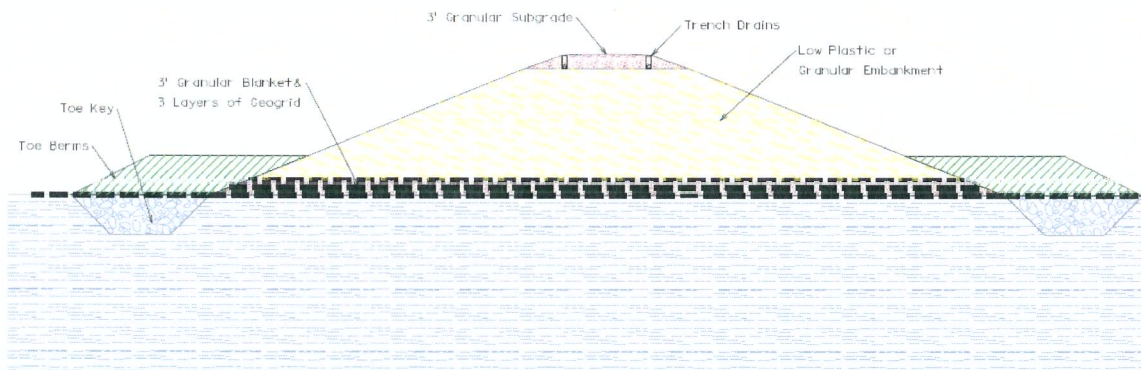


Figure 2. Standard Embankment Mitigation Methods

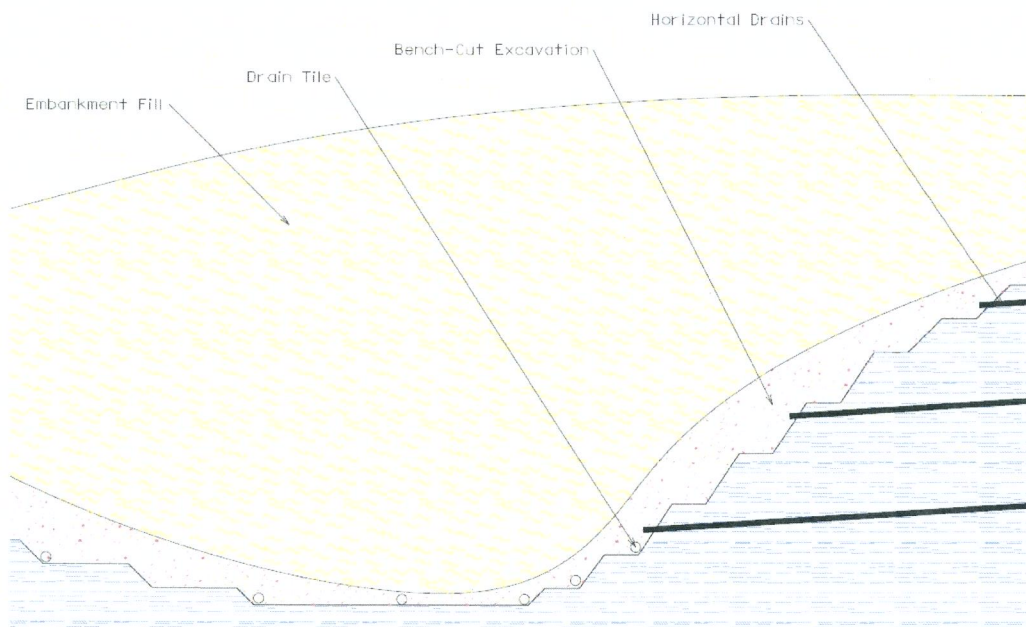


Figure 3. Mitigation Methods on Sloped Fill Segments looking Perpendicular to Roadway

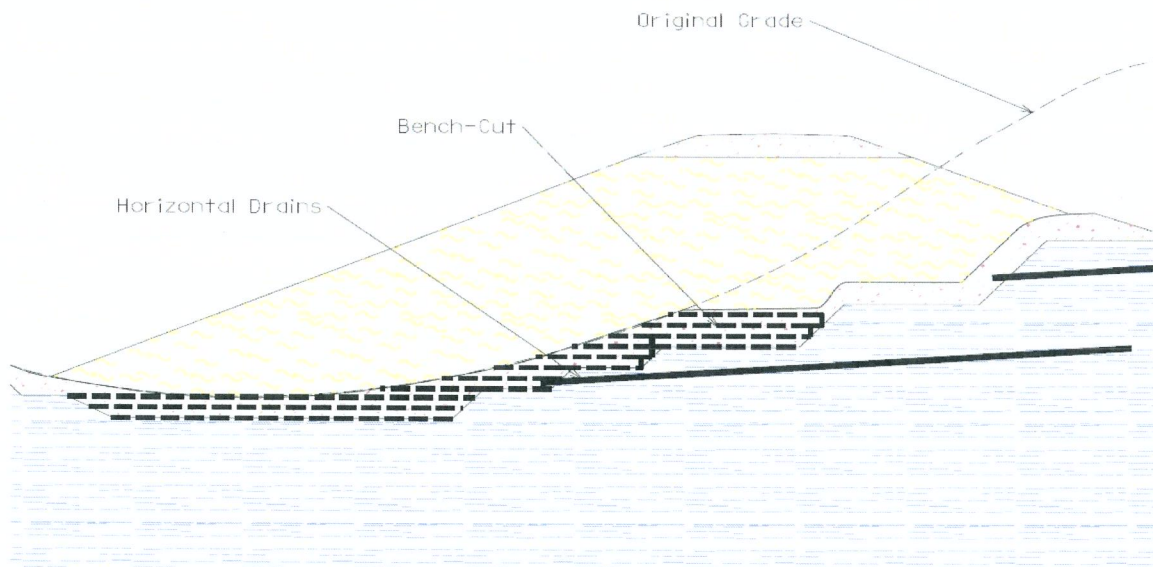


Figure 4. Mitigation Methods on Side-Hill Fill Segments

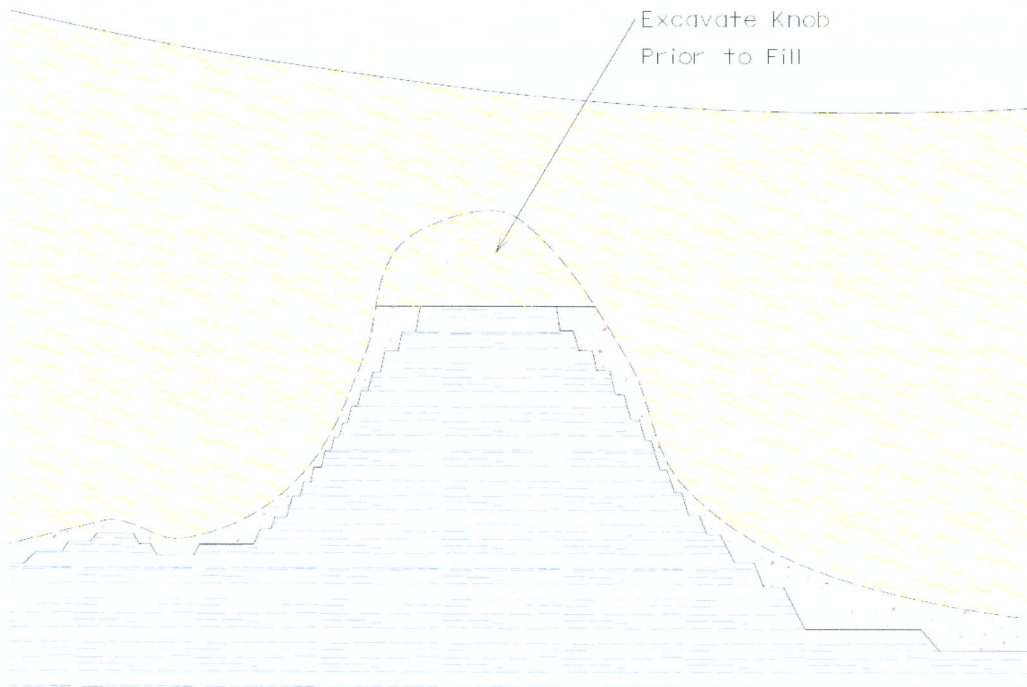


Figure 5. Mitigation Methods Showing Removal of shale "Knobs"

Specific Mitigation Location Descriptions

Tables 1 and 2 describe the recommended mitigation techniques at specific stationing for both the West and East alignment locations, respectively.

Table 1
West Alignment

| Station Beginning | Station End | Cut | Fill | Bridge | Drilled Horizontal Drains | Over-Ex Beneath Roadway | Toe Berms | Bench-Cut Excavation | Shale Knob Cut | Granular Blanket and Geogrid | Toe Key | Subsurface Trench Drains |
|-------------------|-------------|-----|------|--------|---------------------------|-------------------------|-----------|----------------------|----------------|------------------------------|---------|--------------------------|
| 8413+00 | 8490+00 | | x | | | | | | | x | | x |
| 8490+00 | 8517+50 | | x | | x | x | | x | x | x | x | x |
| 8517+50 | 8528+50 | x | | | | | | | | | | x |
| 8528+50 | 8554+00 | | x | | x | | x | x | | x | x | x |
| 8554+00 | 8568+75 | x | | | x | x | | | | | | x |
| 8568+75 | 8584+00 | | x | | | | x | x | x | x | x | x |
| 8584+00 | 8592+50 | x | | | x | x | | | | | | x |
| 8592+50 | 8602+30 | | | x | | | | | | | | |
| 8602+30 | 8664+25 | x | | | x | x | x | | | | | x |
| 8664+25 | 8667+80 | | x | | | | x | x | | x | x | x |
| 8667+80 | 8677+25 | x | | | x | x | x | x | | | | x |
| 8677+25 | 8682+25 | | x | | | | x | x | | x | x | x |
| 8682+25 | 8688+25 | x | | | x | x | x | x | | | | x |
| 8688+25 | 8692+75 | | x | | | | x | x | | x | x | x |
| 8692+75 | 8707+00 | x | | | x | x | x | x | | | | x |
| 8707+00 | 8726+00 | | x | | x | | x | x | x | x | x | x |
| 8726+00 | 8735+75 | x | | | x | x | x | x | | | | x |

Table 2
East Alignment

| Station Beginning | Station End | Cut | Fill | Bridge | Drilled Horizontal Drains | Over-Ex Beneath Roadway | Toe Berms | Bench-Cut Excavation | Shale Knob Cut | Granular Blanket and Geogrid | Toe Key | Subsurface Trench Drains |
|-------------------|-------------|-----|------|--------|------------------------------|-------------------------------|--------------|-------------------------|-------------------|---------------------------------------|---------|--------------------------------|
| 8026+25 | 8065+75 | | x | | | | | | | x | | x |
| 8065+75 | 8075+50 | | x | | x | | | x | | x | x | x |
| 8075+50 | 8083+00 | x | | | x | x | | | | | | x |
| 8083+00 | 8084+50 | | x | | | | | x | | x | x | x |
| 8084+50 | 8092+00 | x | | | x | x | | | | | | x |
| 8092+00 | 8101+75 | | x | | | | x | x | | x | x | x |
| 8101+75 | 8108+50 | x | | | x | x | | | | | | x |
| 8108+50 | 8115+25 | | x | | | | x | x | | x | x | x |
| 8115+25 | 8133+75 | x | | | x | x | x | x | | | | x |
| 8133+75 | 8141+50 | | | x | | | | | | | | x |
| 8141+50 | 8149+75 | x | | | x | x | x | x | | | | x |
| 8149+75 | 8152+50 | | x | | | | x | x | | x | x | x |
| 8152+50 | 8156+50 | x | | | x | x | x | | | | | x |
| 8156+50 | 8163+25 | | x | | | | x | x | | x | x | x |
| 8163+25 | 8167+25 | x | | | x | x | | | | | | x |
| 8167+25 | 8176+00 | | x | | x | | x | x | x | x | x | x |
| 8176+00 | 8196+50 | x | | | x | x | x | x | | | | x |
| 8196+50 | 8207+25 | | x | | | x | x | x | x | x | x | x |
| 8207+25 | 8208+25 | x | | | x | x | | | | | | x |
| 8208+25 | 8209+75 | | x | | | | | | | x | | x |
| 8209+75 | 8215+00 | x | | | | x | | | | | | x |
| 8215+00 | 8218+00 | | x | | | | | x | | x | x | x |
| 8218+00 | 8230+75 | x | | | x | x | x | | | | | x |
| 8230+75 | 8231+75 | | x | | | | | | | x | | x |
| 8231+75 | 8235+50 | x | | | x | x | | | x | | | x |
| 8235+50 | 8240+50 | | x | | | | | x | | x | x | x |
| 8240+50 | 8243+25 | x | | | x | x | | | | | | x |
| 8243+25 | 8244+75 | | x | | | | | x | x | x | | x |
| 8244+75 | 8245+50 | x | | | x | x | | | | | | x |
| 8245+50 | 8248+00 | | x | | | | | x | | x | | x |
| 8248+00 | 8252+25 | x | | | x | x | | | | | | x |
| 8252+25 | 8254+00 | | x | | | | | x | | x | | x |
| 8254+00 | 8256+50 | x | | | x | x | | | | | | x |
| 8256+50 | 8259+50 | | x | | | | | x | | x | x | x |
| 8259+50 | 8276+50 | x | | | x | x | x | | | | | x |
| 8276+50 | 8286+00 | | | x | | | | | | | | x |
| 8286+00 | 8317+75 | | x | | | | | x | | x | | x |

As previously discussed, each cut and fill section will require extensive drilling, sampling, and testing to provide sufficient information for the stability and settlement analysis for the proposed West and East B1 Alignments. Past experience has exhibited that constructing roadways within the shale areas in the northwest part of Nebraska typically results in stability problems and continuous maintenance issues. The recommendations provided are the best that can be provided at this time. Please feel free to contact the Geotechnical Section with any questions and comments.

cc: Moe Jamshidi, Operations Engineer
Mick Syslo, M&R Engineer
Jim Knott, Roadway Design Engineer
file

PROPOSED CULVERT AND BRIDGE SIZES

Existing Drainage Structures on the Niobrara East and West Project

| As-Built Used | As-Built Station | Pipe Size | Description | A1 Alignment | A1 |
|--------------------------|------------------|---------------------------|------------------------|--------------|------------------------------------|
| CN 30775 F-12-5(1002) | 33+35.00 | 36"x76' | BB CM Pipe w/Hdwls | 1402+97.00 | Outside Project Limits |
| | 55+80.00 | 2-80' & 1-120' Spans | Steel Girder Bridge | 1426+40.00 | 280' Span Bridge |
| | 75+50.00 | 24"x60' | CM Pipe w/Hdwls | 1446+12.00 | 5' x 5' x 129' Box Culvert |
| | 91+80.00 | 8'x8'x103' | CBC | 1462+43.00 | 160' Span Bridge |
| | | None | | 1468+08.00 | N/A |
| | 100+20.00 | 1-24'-6" & 2-17'-9" Span | Concrete Slab Bridge | 1470+85.00 | 150' Span Bridge |
| | 109+50.00 | 24"x82' | CM Pipe w/Hdwls | 1480+12.00 | Twin 8' x 5' x 105' Box Culvert |
| | 112+50.00 | 24" x 80' | CM Pipe w/Hdwls | 1483+12.00 | Triple 8' x 8' x 104' Box Culvert |
| | 118+00.00 | 24"x76' | CM Pipe w/Hdwls | 1488+61.00 | Quad 12' x 8' x 98' Box Culvert |
| | N/A | None | | 1505+83.00 | 8' x 7' x 133' Box Culvert |
| | 158+00.00 | 24"x64' | CM Pipe w/Hdwls | 1528+62.00 | 10' x 8' x 139' Box Culvert |
| | 172+00.00 | 24"x58' | CM Pipe w/Hdwls | 1542+75.00 | Triple 10' x 8' x 147' Box Culvert |
| | 175+53.50 | 3-12' Spans | Concrete Slab Bridge | 1546+02.00 | Triple 12' x 8' x 165' Box Culvert |
| | 182+00.00 | 24"x80' | CM Pipe w/Hdwls | 1552+62.00 | 5' x 4' x 167' Box Culvert |
| | 194+00.00 | 36"x152' | CM Pipe w/Hdwls | 1564+43.00 | 14' x 7' x 238' Box Culvert |
| | 203+00.00 | 24"x74' | CM Pipe w/Hdwls | 1573+64.00 | Twin 7' x 7' x 165' Box Culvert |
| | 220+55.00 | 1-24'-6" & 2-17'-9" Spans | Concrete Slab Bridge | 1591+14.00 | 90' Span Bridge |
| | 228+00.00 | 24"x66' | CM Pipe w/Hdwls | 1598+62.00 | 12' x 6' x 163' Box Culvert |
| | 254+00.00 | 24"x60' | CM Pipe w/Hdwls | 1624+62.00 | 12' x 6' x 168' Box Culvert |
| | 266+50.00 | 5'x6'x50' | CBC | 1637+05.00 | 10' x 9' x 246' Box Culvert |
| | N/A | 24"x90' | CM Pipe w/Hdwls | 1662+46.00 | Twin 9' x 9' x 177' Box Culvert |
| | N/A | 24"x66' | CM Pipe w/Hdwls | 1671+45.00 | Twin 9' x 9' x 195' Box Culvert |
| | 331+03.00 | 12'x9'x41 | CBC | 1701+71.00 | 10' x 9' x 176' Box Culvert |
| | 340+50.00 | 24"x64' | CM Pipe w/Hdwls | | None |
| | 343+00.00 | 1-40' Span | Concrete Slab Bridge | 1713+73.00 | Quad 10' x 10' x 214' Box Culvert |
| | 346+10.00 | 24"x56' | CM Pipe w/Hdwls | | None |
| | 349+58.00 | 54"x156' | DBL BB CM Pipe w/Hdwls | | None |
| | 353+30.00 | 36"x178' | DNL BB CM Pipe w/Hdwls | | None |
| END OF WEST SEGMENT | | | | | |
| CN 30264 F-12-5(102) | | None | | 1049+00.00 | 9' x 8' x 178' Box Culvert |
| | 159+79.00 | Twin 6'x5'x66' | CBC | 1065+00.00 | 12' x 8' x 180' Box Culvert |
| | 169+00.00 | 24"x72' | CMP w/FES | 176+70.00 | 12' x 8' x 184' Box Culvert |
| S-714(2) | 185+52.00 | Triple 8'x4'x66' | CBC | 1091+75.00 | Twin 12' x 8' x 176' Box Culvert |
| | 95+00.00 | 8'x5'x40' | CBC | 1101+80.00 | 10' x 8' x 178' Box Culvert |
| | 101+42.00 | 8'x4'x37' | CBC | 1108+21.00 | 10' x 8' x 194' Box Culvert |
| | 124+54.00 | 24"x48' | CM Pipe w/Hdwls | | None |
| | 125+45.00 | Triple 10'x6'x36' | CBC | 1132+32.00 | Triple 10' x 7' x 134' Box Culvert |
| | 145+00.00 | 8'x5'x36' | CBC | 1151+82.00 | Quad 12' x 9' x 147' Box Culvert |
| | 160+00.00 | 24"x52' | CM Pipe w/Hdwls | | None |
| | 165+00.00 | 10'x4'x53' | CBC | 1171+80.00 | 12' x 9' x 181' Box Culvert |
| | | None | | 1176+89.00 | 10' x 10' x 187' Box Culvert |
| | 181+70.00 | 24"x78' | CM Pipe w/Hdwls | | None |
| | | None | | 1189+88.00 | 12' x 10' x 166' Box Culvert |
| | 192+00.00 | 48"x48' | CM Pipe w/Hdwls | 1198+82.00 | 10' x 9' x 198' Box Culvert |
| | | None | | 1218+40.00 | 10' x 8' x 157' Box Culvert |
| | N/A | 7'x7'x62' | CBC | 1247+97.00 | 920' Span Bridge |
| | 241+20.00 | 230' Span | D.S.G Bridge | | |
| | 251+50.00 | 24"x44' | CM Pipe w/Hdwls | | None |
| | 258+00.00 | 24"x64' | BB CM Pipe w/Hdwls | | None |
| | 262+16.00 | 24"x88' | BB CM Pipe w/Hdwls | | None |
| | 264+95.00 | 24"x80' | CM Pipe w/Hdwls | | None |
| | 268+90.00 | 48"x68' | CM Pipe w/Hdwls | | None |
| | | None | | 1282+85.00 | 8' x 8' x 106' Box Culvert |
| | 286+00.00 | 24"x51' | CM Pipe w/Hdwls | | None |
| | 294+50.00 | 8'x3'x43' | CBC | 1301+24.00 | 8' x 8' x 123' Box Culvert |
| | 304+50.00 | Triple 12'x12'x49' | CBC | 1311+27.00 | Quad 11' x 10' x 140' |
| END OF EAST SEGMENT | | | | | |

Existing Drainage Structures on the Niobrara East and West Project

| As-Built Used | As-Built Station | Pipe Size | Description | A2 Alignment | A2 Structure | A4 Structure | |
|--------------------------|---------------------|---------------------------|-------------------------|------------------------------------|---|------------------------------------|----------------------------|
| CN 30775 F-12-5(1002) | 33+35.00 | 36"x76' | BB CM Pipe w/Hdwl's | 2402+97.00 | Outside Project Limits | Outside Project Limits | |
| | 55+80.00 | 2-80' & 1-120' Spans | Steel Girder Bridge | 2427+66.00 | 280' Span Bridge | 280' Span Bridge | |
| | 75+50.00 | 24"x60' | CM Pipe w/Hdwl's | 2446+23.00 | 5' x 5' x 121' Box Culvert | 5' x 5' x 121' Box Culvert | |
| | 91+80.00 | 8'x8'x103' | CBC | 2462+06.00 | 160' Span Bridge | 160' Span Bridge | |
| | | None | | 2468+02.00 | 60' x 106' Pipe Culvert | 60' x 106' Pipe Culvert | |
| | 100+20.00 | 1-24'-6" & 2-17'-9" Span | Concrete Slab Bridge | 2470+81.00 | 150' Span Bridge | 150' Span Bridge | |
| | 109+50.00 | 24"x82' | CM Pipe w/Hdwl's | 2480+08.00 | Twin 8' x 5' x 97' Box Culvert | Twin 8' x 5' x 97' Box Culvert | |
| | 112+50.00 | 24" x 80' | CM Pipe w/Hdwl's | 2483+07.00 | Triple 8' x 8' x 108' Box Culvert | Triple 8' x 8' x 108' Box Culvert | |
| | 118+00.00 | 24"x76' | CM Pipe w/Hdwl's | 2488+56.00 | Quad 12' x 8' x 107' Box Culvert | Quad 12' x 8' x 107' Box Culvert | |
| | N/A | None | | 2505+78.00 | 8' x 7' x 117' Box Culvert | 8' x 7' x 117' Box Culvert | |
| | 158+00.00 | 24"x64' | CM Pipe w/Hdwl's | 2528+57.00 | 10' x 8' x 134' Box Culvert | 10' x 8' x 134' Box Culvert | |
| | 172+00.00 | 24"x58' | CM Pipe w/Hdwl's | 2542+70.00 | Triple 10' x 6' x 148' Box Culvert | Triple 10' x 6' x 148' Box Culvert | |
| | 175+53.50 | 3-12' Spans | Concrete Slab Bridge | 2546+47.00 | Triple 12' x 8' x 151' Box Culvert | Triple 12' x 8' x 151' Box Culvert | |
| | 182+00.00 | 24"x80' | CM Pipe w/Hdwl's | 2552+56.00 | 5' x 4' x 152' Box Culvert | 5' x 4' x 152' Box Culvert | |
| | 194+00.00 | 36"x152' | CM Pipe w/Hdwl's | 2563+25.00 | 14' x 7' x 219' Box Culvert | 14' x 7' x 219' Box Culvert | |
| | 203+00.00 | 24"x74' | CM Pipe w/Hdwl's | 2573+29.00 | Twin 7' x 7' x 166' Box Culvert | Twin 7' x 7' x 166' Box Culvert | |
| | 220+55.00 | 1-24'-6" & 2-17'-9" Spans | Concrete Slab Bridge | 2591+37.00 | 90' Span Bridge | 90' Span Bridge | |
| | 228+00.00 | 24"x66' | CM Pipe w/Hdwl's | 2598+41.00 | 12' x 6' x 170' Box Culvert | 12' x 6' x 170' Box Culvert | |
| | 254+00.00 | 24"x60' | CM Pipe w/Hdwl's | 2624+41.00 | 12' x 6' x 168' Box Culvert | | |
| | 266+50.00 | 5'x6'x50' | CBC | 2637+45.00 | 10' x 9' x 205' Box Culvert | | |
| | N/A | 24"x90' | CM Pipe w/Hdwl's | 2662+25.00 | Twin 9' x 9' x 171' Box Culvert | | |
| | N/A | 24"x66' | CM Pipe w/Hdwl's | 2670+74.00 | Twin 9' x 9' x 175' Box Culvert | | |
| | 331+03.00 | 12'x9'x41 | CBC | 2701+00.00 | 10' x 9' x 182' Box Culvert | 6 - 1400' Span Bridges | |
| | 340+50.00 | 24"x64' | CM Pipe w/Hdwl's | | None | | |
| | 343+00.00 | 1-40' Span | Concrete Slab Bridge | 2713+57.00 | Quad 10' x 10' x 10' x 149' Box Culvert | | |
| | 346+10.00 | 24"x56' | CM Pipe w/Hdwl's | | None | | |
| | 349+58.00 | 54"x156' | DBL BB CM Pipe w/Hdwl's | | None | | |
| | 353+30.00 | 36"x178' | DNL BB CM Pipe w/Hdwl's | | None | | |
| | END OF WEST SEGMENT | | | | | | |
| | | | None | | 2048+73.00 | 9' x 8' x 166' Box Culvert | 9' x 8' x 166' Box Culvert |
| CN 30264 F-12-5(1002) | 159+79.00 | Twin 6'x5'x66' | CBC | 2064+75.00 | 12' x 8' x 179' Box Culvert | 525' Span Bridge | |
| | 169+00.00 | 24"x72' | CMF w/FES | 2076+42.00 | 12' x 8' x 183' Box Culvert | 12' x 8' x 183' Box Culvert | |
| | | | | 2083+00.00 | None | 1050' Span Bridge | |
| | 185+52.00 | Triple 8'x4'x66' | CBC | 2091+37.00 | Twin 12' x 8' x 159' Box Culvert | Twin 12' x 8' x 159' Box Culvert | |
| | 95+00.00 | 8'x5'x40' | CBC | 2101+39.00 | 10' x 8' x 175' Box Culvert | 2 - 1400' Span Bridges | |
| 101+42.00 | 8'x4'x37' | CBC | 2107+80.00 | 10' x 8' x 185' Box Culvert | | | |
| 124+54.00 | 24"x48' | CM Pipe w/Hdwl's | | None | | | |
| 125+45.00 | Triple 10'x6'x36' | CBC | 2131+94.00 | Triple 10' x 7' x 116' Box Culvert | Triple 10' x 7' x 116' Box Culvert | | |
| S-714(2) | 145+00.00 | 8'x5'x36' | CBC | 2151+41.00 | Quad 12' x 9' x 148' Box Culvert | Quad 12' x 9' x 148' Box Culvert | |
| | 160+00.00 | 24"x52' | CM Pipe w/Hdwl's | | None | | |
| | 165+00.00 | 10'x4'x53' | CBC | 2171+46.00 | 12' x 9' x 168' Box Culvert | | |
| | | None | | 2176+95.00 | 10' x 10' x 176' Box Culvert | | 1 - 1400' Span Bridge |
| | 181+70.00 | 24"x78' | CM Pipe w/Hdwl's | | None | | 1 - 1275' Span Bridge |
| | | None | | 2189+96.00 | 12' x 10' x 172' Box Culvert | 1 - 1300' Span Bridge | |
| | 192+00.00 | 48"x48' | CM Pipe w/Hdwl's | 2198+78.00 | 10' x 9' x 175' Box Culvert | 1 - 700' Span Bridge | |
| | | None | | 2218+47.00 | 10' x 8' x 158' Box Culvert | | |
| | N/A | 7'x7'x62' | CBC | | | | |
| | 241+20.00 | 230' Span | D.S.G Bridge | 2248+34.00 | 1020' Span Bridge | 1020' Span Bridge | |
| | 251+50.00 | 24"x44' | CM Pipe w/Hdwl's | | None | None | |
| | 258+00.00 | 24"x64' | BB CM Pipe w/Hdwl's | | None | None | |
| | 262+16.00 | 24"x88' | BB CM Pipe w/Hdwl's | | None | None | |
| | 264+95.00 | 24"x80' | CM Pipe w/Hdwl's | | None | None | |
| | 268+90.00 | 48"x68' | CM Pipe w/Hdwl's | | None | None | |
| | | None | | 2283+94.00 | 8' x 8' x 129' Box Culvert | 8' x 8' x 129' Box Culvert | |
| | 286+00.00 | 24"x51' | CM Pipe w/Hdwl's | | None | None | |
| | 294+50.00 | 8'x3'x43' | CBC | 2302+13.00 | 8' x 8' x 121' Box Culvert | 8' x 8' x 121' Box Culvert | |
| | 304+50.00 | Triple 12'x12'x49' | CBC | 2311+94.00 | Quad 11' x 10' x 142' | Quad 11' x 10' x 142' | |
| | END OF EAST SEGMENT | | | | | | |

Existing Drainage Structures on the Niobrara East and West Project

| As-Built Used | As-Built Station | Pipe Size | Description | A3 Alignment | A3 | A7 |
|--------------------------|------------------|---------------------------|------------------------|--------------|------------------------------------|------------------------------------|
| CN 30775 F-12-5(1002) | 33+35.00 | 36"x76' | BB CM Pipe w/Hdwls | 3402+97.00 | Outside Project Limits | Outside Project Limits |
| | 55+80.00 | 2-80' & 1-120' Spans | Steel Girder Bridge | 3427+52.00 | 280' Span Bridge | 280' Span Bridge |
| | 75+50.00 | 24"x60' | CM Pipe w/Hdwls | 3446+16.00 | 5' x 5' x 131' Box Culvert | 5' x 5' x 131' Box Culvert |
| | 91+80.00 | 8"x8'x103' | CBC | 3462+08.00 | 160' Span Bridge | 160' Span Bridge |
| | | None | | 3468+00.00 | 60" x 104' Pipe Culvert | 60" x 104' Pipe Culvert |
| | 100+20.00 | 1-24'-6" & 2-17'-9" Span | Concrete Slab Bridge | 3470+83.00 | 150' Span Bridge | 150' Span Bridge |
| | 109+50.00 | 24"x82' | CM Pipe w/Hdwls | 3480+10.00 | Twin 8' x 5' x 109' Box Culvert | Twin 8' x 5' x 109' Box Culvert |
| | 112+50.00 | 24" x 80' | CM Pipe w/Hdwls | 3483+09.00 | Triple 8' x 6' x 109' Box Culvert | Triple 8' x 6' x 109' Box Culvert |
| | 118+00.00 | 24"x76' | CM Pipe w/Hdwls | 3488+58.00 | Quad 12' x 6' x 106' Box Culvert | Quad 12' x 6' x 106' Box Culvert |
| | N/A | None | | 3505+80.00 | 8' x 7' x 126' Box Culvert | 8' x 7' x 126' Box Culvert |
| | 158+00.00 | 24"x64' | CM Pipe w/Hdwls | 3526+00.00 | 10' x 8' x 152' Box Culvert | 10' x 8' x 152' Box Culvert |
| | 172+00.00 | 24"x58' | CM Pipe w/Hdwls | 3538+00.00 | 10' x 6' x 121' Box Culvert | 10' x 6' x 121' Box Culvert |
| | 175+53.50 | 3-12' Spans | Concrete Slab Bridge | 3550+00.00 | Triple 12' x 8' x 168' Box Culvert | Triple 12' x 8' x 168' Box Culvert |
| | 182+00.00 | 24"x80' | CM Pipe w/Hdwls | 3562+50.00 | 60" x 170' Pipe Culvert | 60" x 170' Pipe Culvert |
| | 194+00.00 | 36"x152' | CM Pipe w/Hdwls | 3566+00.00 | 10' x 8' x 196' Box Culvert | 10' x 8' x 196' Box Culvert |
| | 203+00.00 | 24"x74' | CM Pipe w/Hdwls | 3581+80.00 | 60" x 158' Pipe Culvert | 60" x 158' Pipe Culvert |
| | 220+55.00 | 1-24'-6" & 2-17'-9" Spans | Concrete Slab Bridge | 3594+60.00 | 190' Span Bridge | 190' Span Bridge |
| | 228+00.00 | 24"x66' | CM Pipe w/Hdwls | 3607+00.00 | 42" x 154' Pipe Culvert | 42" x 154' Pipe Culvert |
| | 254+00.00 | 24"x60' | CM Pipe w/Hdwls | 3615+00.00 | 48" x 190' Pipe Culvert | 48" x 190' Pipe Culvert |
| | 266+50.00 | 5'x6'x50' | CBC | 3629+00.00 | 54" x 164' Pipe Culvert | 54" x 164' Pipe Culvert |
| | | None | | 3636+50.00 | 54" x 184' Pipe Culvert | 54" x 184' Pipe Culvert |
| | | None | | 3645+50.00 | 60" x 177' Pipe Culvert | 60" x 177' Pipe Culvert |
| | | None | | 3654+00.00 | 9' x 6' x 186' Box Culvert | 9' x 6' x 186' Box Culvert |
| | | None | | 3665+00.00 | 9' x 6' x 172' Box Culvert | |
| | N/A | 24"x90' | CM Pipe w/Hdwls | | None | 625' Span Bridge |
| | N/A | 24"x66' | CM Pipe w/Hdwls | 3673+80.00 | 12' x 10' x 174' Box Culvert | 425' Span Bridge |
| | 331+03.00 | 12"x9'x41 | CBC | 3693+50.00 | 300' Span Bridge | 2 - 950' Span Bridges |
| | 340+50.00 | 24"x64' | CM Pipe w/Hdwls | 3700+00.00 | 12' x 10' x 158' Box Culvert | |
| | | None | | 3703+00.00 | 30" x 178' Pipe Culvert | 30" x 178' Pipe Culvert |
| | 343+00.00 | 1-40' Span | Concrete Slab Bridge | 3709+91.00 | Quad 10' x 10' x 148' Box Culvert | Quad 10' x 10' x 148' Box Culvert |
| | 346+10.00 | 24"x56' | CM Pipe w/Hdwls | | None | None |
| | 349+58.00 | 54"x156' | DBL BB CM Pipe w/Hdwls | | None | None |
| | 353+30.00 | 36"x178' | DNL BB CM Pipe w/Hdwls | | None | None |
| END OF WEST SEGMENT | | | | | | |
| | | None | | 3049+00.00 | 9' x 4' x 179' Box Culvert | 9' x 4' x 179' Box Culvert |
| | | None | | 3054+00.00 | 8' x 7' x 207' Box Culvert | 8' x 7' x 207' Box Culvert |
| CN 30264 F-12-5(102) | 159+79.00 | Twin 6'x5'x66' | CBC | 3068+18.00 | 8' x 7' x 127' Box Culvert | 8' x 7' x 127' Box Culvert |
| | 169+00.00 | 24"x72' | CMP w/FES | 3082+00.00 | 10' x 8' x 141' Box Culvert | 10' x 8' x 141' Box Culvert |
| | 185+52.00 | Triple 8'x4'x66' | CBC | 3094+72.00 | 12' x 10' x 82' Box Culvert | 12' x 10' x 82' Box Culvert |
| S- | 95+00.00 | 8'x5'x40' | CBC | 3104+00.00 | 6' x 6' x 127' Box Culvert | 6' x 6' x 127' Box Culvert |
| | 101+42.00 | 8'x4'x37' | CBC | 3112+40.00 | 10' x 10' x 145' Box Culvert | 10' x 10' x 145' Box Culvert |
| | 124+54.00 | 24"x48' | CM Pipe w/Hdwls | 3121+00.00 | 10' x 10' x 89' Box Culvert | 10' x 10' x 89' Box Culvert |
| | | None | | 3125+50.00 | 30" x 130' Pipe Culvert | 30" x 130' Pipe Culvert |
| | | None | | 3128+00.00 | 30" x 123' Pipe Culvert | 30" x 123' Pipe Culvert |
| | 125+45.00 | Triple 10'x6'x36' | CBC | 3138+50.00 | 10' x 9' x 81' Box Culvert | 10' x 9' x 81' Box Culvert |
| | 145+00.00 | 8'x5'x36' | CBC | 3152+29.00 | Quad 12' x 12' x 127' Box Culvert | Quad 12' x 12' x 127' Box Culvert |
| | | None | | 3160+00.00 | 10' x 8' x 97' Box Culvert | 10' x 8' x 97' Box Culvert |
| | 160+00.00 | 24"x52' | CM Pipe w/Hdwls | | None | None |
| | 165+00.00 | 10'x4'x53' | CBC | 3174+00.00 | 12' x 12' x 165' Box Culvert | 12' x 12' x 165' Box Culvert |